Maj. Jim Shoemaker
Tactical Technology Office (TTO)
Orbital Express

Hello, I'm Jim Shoemaker, and I'm the program manager for the Orbital Express on-orbit satellite servicing demonstration.

Orbital Express will validate the technical feasibility of autonomous rendezvous, proximity operations, docking and robotic servicing of satellites. However, the long term objective of Orbital Express is to change the way that the U.S. operates in space.

The two primary servicing functions we want to demonstrate are refueling and electronic box change-out, which we call Orbital Replacement Units or ORUs.

Why do we want to refuel satellites? Right now, every time we maneuver a satellite we shorten its life because is has a fixed amount of fuel onboard—so we only move satellites around in times of crisis. With refueling, satellite maneuvering will become routine, improving tactical coverage and increasing satellite survivability.

Why do we want to replace electronics?

C H A R T 4

This graph shows half the reason that upgrading satellites makes sense: we're building satellites that can last for 20 years. And a lot of the big, heavy components on the satellites don't really change that much over time. We can make power supplies and support structures better and lighter than we could 20 years ago, but not by factors of 10 better.

C H A R T 5

What does get really changed dramatically is the electronics. This graph just shows the Moore's law doubling of computer performance every 18 months. The Hubble space telescope performance has been improved by over a factor of 100 since its launch: same mirror, upgraded detectors and electronics.

Of course, without that on-orbit repair mission, Hubble wouldn't be very interesting to many people right now. If you think about it, right now we do amazing things with 50 year-old airplanes because we could replace avionics, but the only way to upgrade one of our satellites is to throw it away and replace it.

C H A R T 6

What do we see as the key elements of an operational on-orbit servicing infrastructure? First, we have a multi-use delivery truck, the ASTRO servicer. The ASTRO needs a lot of expensive components to operate—like sensors, a refueling system, and robotic arms—and you don't want to pay that bill every time you service a satellite.

You don't buy a new set of tools every time you change the oil in your car. ASTRO is a robot. Humans are a lot more capable than robots, but getting people into space is a lot more expensive. Robots can work effectively, provided when you keep the servicing tasks relatively simple and well defined. Since we've made the reusable ASTRO very capable, we can make the consumable supplies rather simple, launching fuel and avionics in bare bones supply depots that we store on orbit for preplanned upgrades and refueling.

C H A R T 7

If a satellite breaks, Murphy will tell you that the part that broke is guaranteed to be the one that you left at home.

So, we envision using RASCAL, a responsive launch vehicle that you heard about earlier afternoon, to send up parts on short notice. ASTRO will also be able to pick up microsats that RASCAL launches, refuel them, and send them on their merry way. The weight you save in fuel you can put into payload, so you can put a lot of capability into a small package.

C H A R T 8

Of course, we'll need to redesign our satellites to enable them to be serviced, adding refueling ports, and expansion slots for electronics.

This next generation of satellites, or NextSats, will include a standard interface so that one ASTRO can service many different types of satellites.

We don't build new aerial tankers every time we buy a new fighter; the fighter contractor knows what the fuel hose looks like, and builds a plug to fit the hose.

If you squint really hard, you might be able to make out the last important component of Orbital Express, but we're putting in a lot of effort to make sure it is hard to notice: the 2 mammal ground station, a boy and a dog. The boy is there to feed the dog; the dog is there to make sure the boy doesn't touch any of the knobs.

Since we're building an autonomous system, we won't need a huge standing army watching blips on scopes to operate the system, and we won't have to pay them either

C H A R T 9

Its difficult to visualize how all this will work, so I'm going to show a cartoon that illustrates our concept for the Orbital Express system, and how the hardware and software we test will transition to an operational system.

C H A R T 1 0

DARPA believes that routine, autonomous satellite servicing can change the way we operate in space, maneuvering at will, doubling onboard computer power, re-engineering satellites on orbit. Robotic on-orbit satellite servicing isn't a new idea, and it has looked good on paper in a number of studies, but no one has been willing to bite-off the risk and develop a system. Orbital Express will tackle the dreaded viewgraph to hardware transition, and make on-orbit servicing a reality.